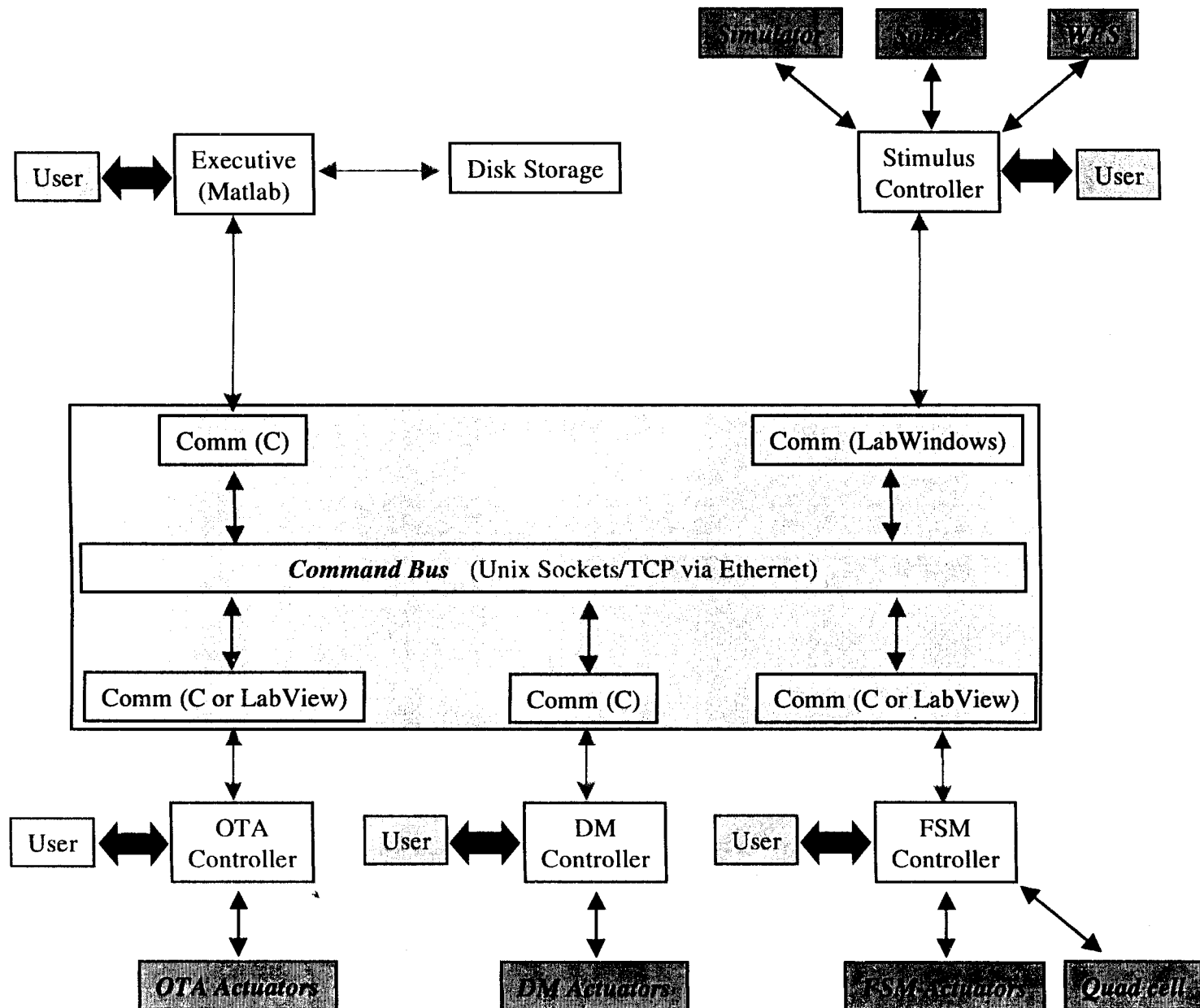# Controlling the DCATT/NEXCAT Hardware
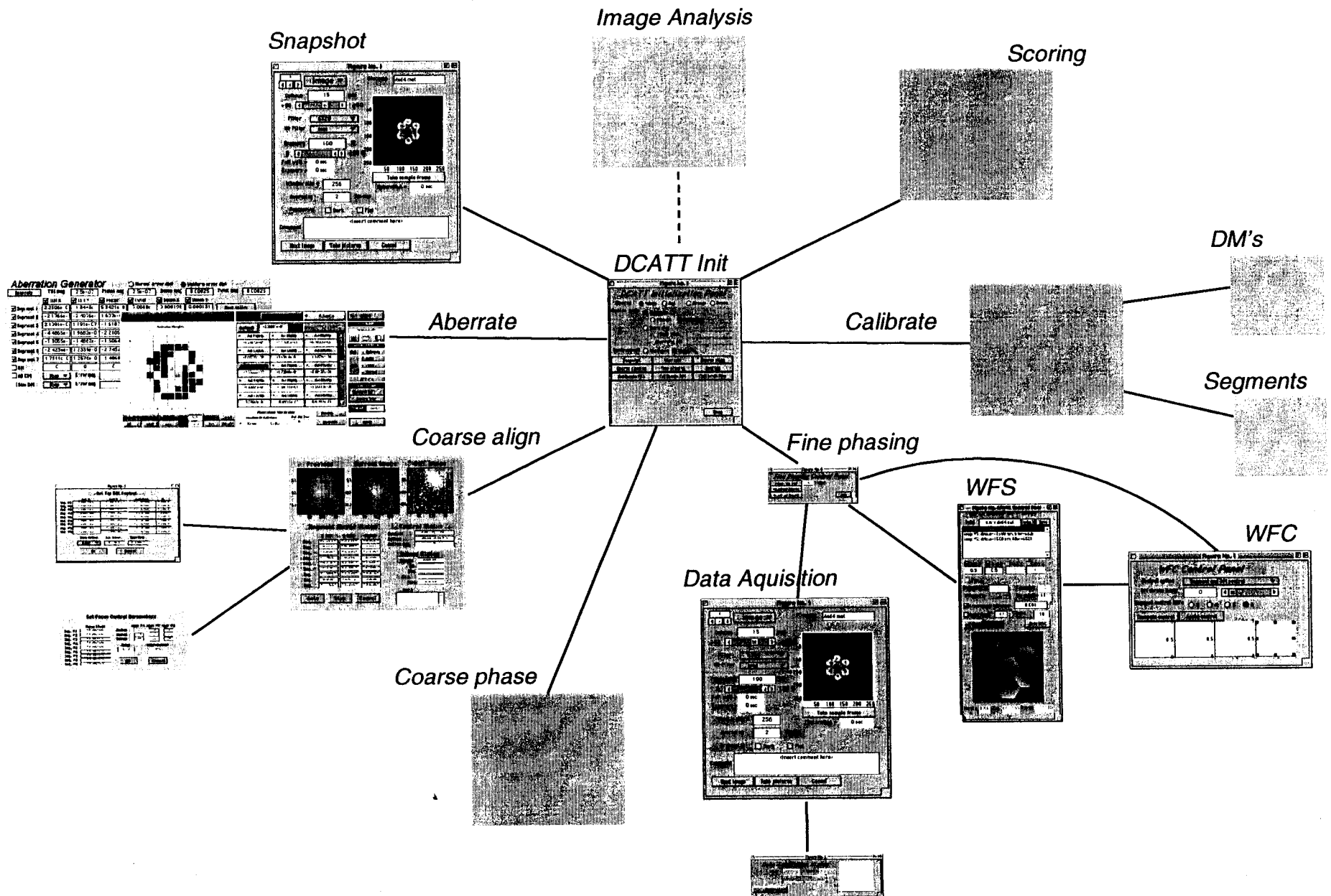
Scott Basinger, Laura Burns, David Redding
Brendon Perkins, Ladd Wheeler, Jennifer Deering

DCATT Architecture Summary
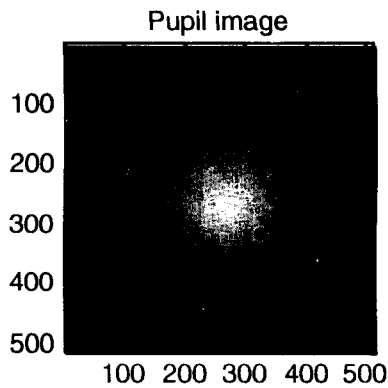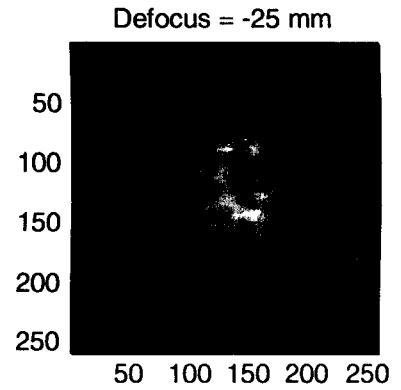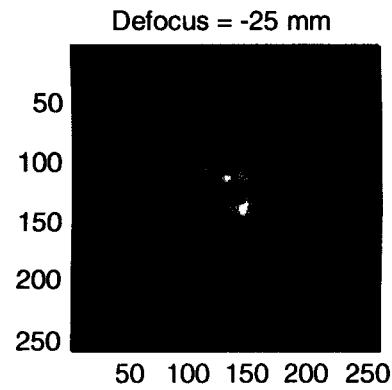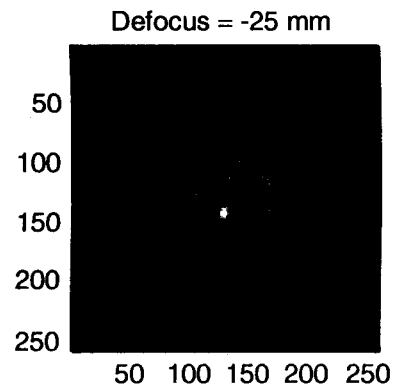
Executive Overall Flow Diagram

Snapshot

Image Analysis

Scoring

DCATT Init

DM's

Aberrate

Calibrate

Segments

Coarse align

Fine phasing

WFS

WFC

Data Aquisition

Coarse phase

Typical Images

Defocus = -25 mm

Defocus = -25 mm

Defocus = -25 mm

Defocus = -25 mm

Pupil image

Defocussed images taken for WF sensing
Nominal defocus = --25, -12.5, 12.5 and 25 mm
DM actuators all at 1/8 max stroke
Images show stripes due to OAP figure errors,
*   astigmatism, DM actuator features*
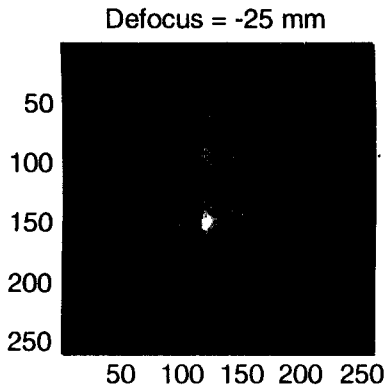
Pupil image
White light source
632.8±1.5nm filter
40 sec exposure

Shows slight offset,
taper at edge
Truncated gaussian profile

• Images from first data run

WFS and Zygo Measurements: Return Mirror

Retrieved phase, SSC with RM

Zygo phase, SSC with RM

Retrieved - Zygo phase
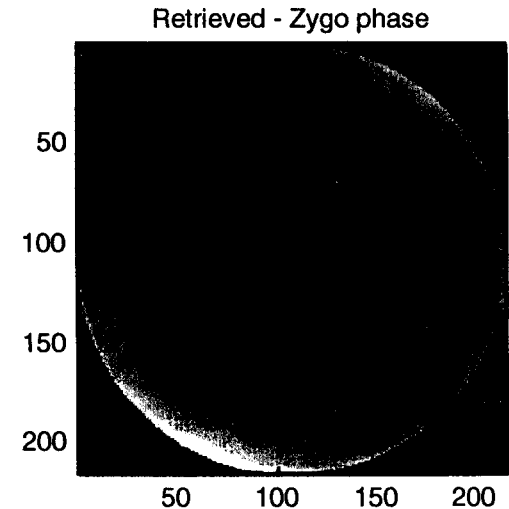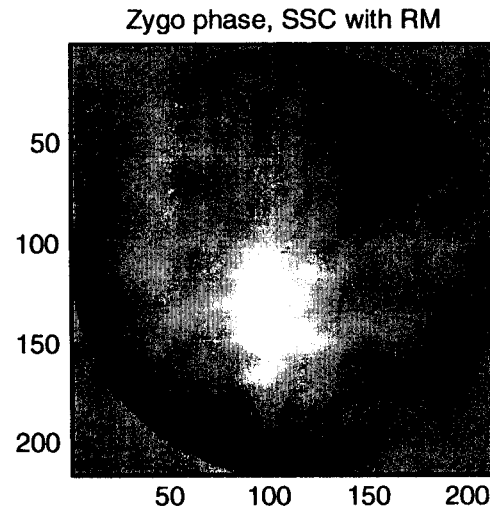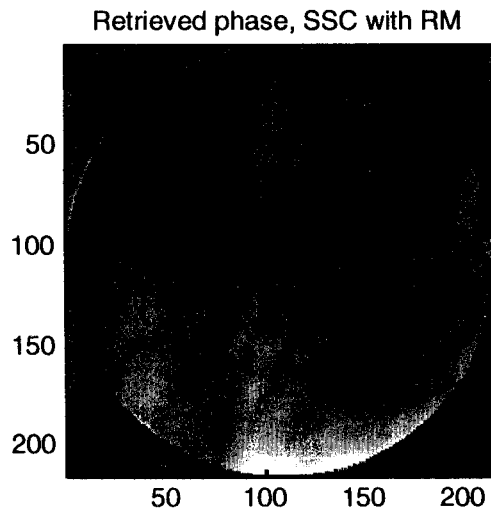
- **WFS results show gouges in OAP from figuring and polishing during OAP manufacture**

  - **Consistent in both measurements, removed in difference frame**

- **Zygo measurement shows bump, focus, astigmatism missing in WFS results**

- **Zygo measurements noisy, differences from frame to frame up to 0.1 wave in astigmatism and coma**

- **WFS results show ring artifacts**

Zygo Transmission Sphere Surface Map
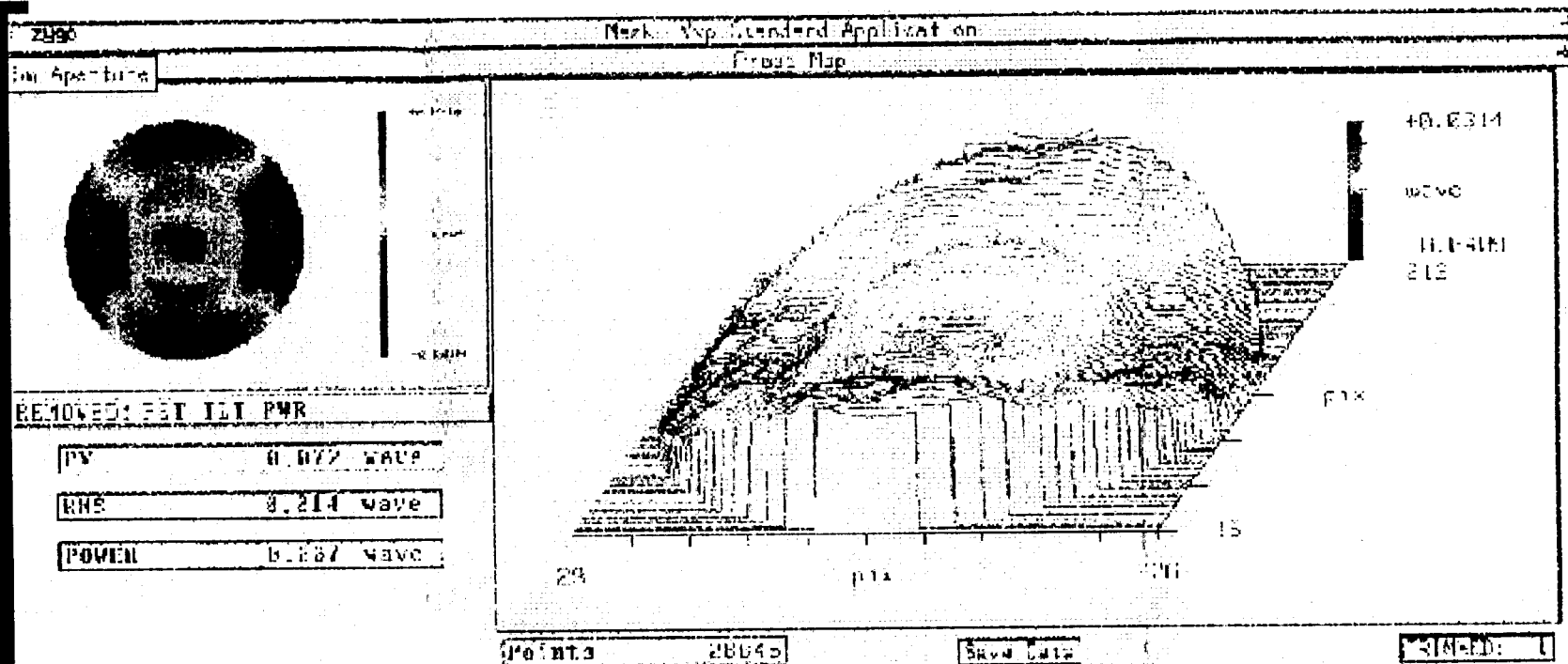
- **Shows surface map of Zygo transmission sphere -- part of total non-common path error between DCATT WFS and Zygo measurements**

- **Qualitatively consistent with WFS - Zygo residuals**
  - **Magnitude, astigmatic character, dip near center**
  - **Residuals also include BS non-common path effects**

WFS and Zygo Measurements: Deformable Mirror

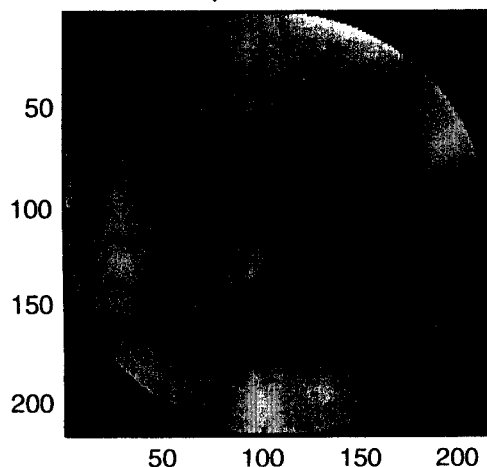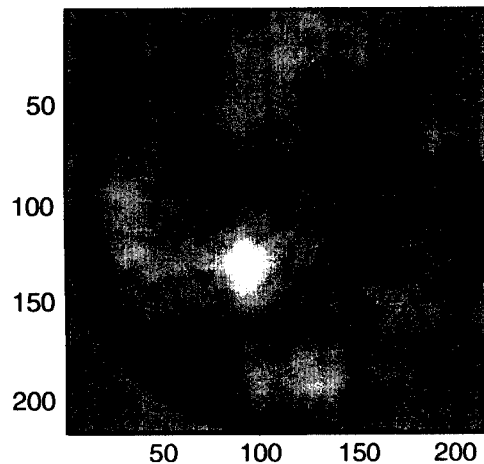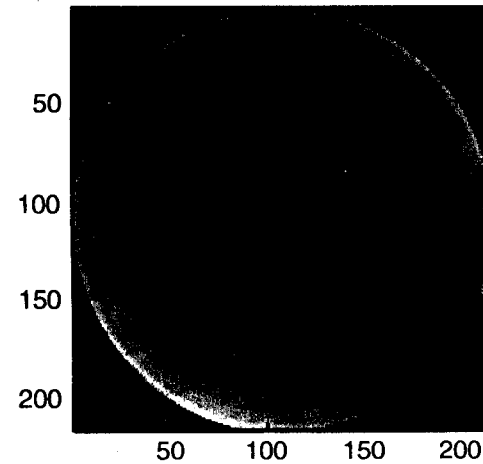Retrieved phase, SSC with DM   Zygo phase, SSC with DM   Retrieved - Zygo phase

- **Shows surface map of Zygo transmission sphere -- part of total non-common path error between DCATT WFS and Zygo measurements**

- **Qualitatively consistent with WFS - Zygo residuals**
  - **Magnitude, astigmatic character, dip near center**
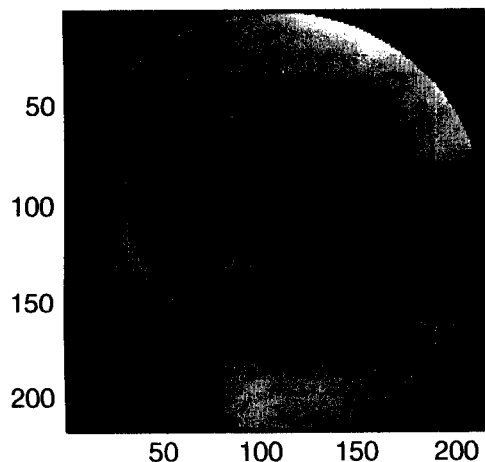 - **Residuals also include BS non-common path effects**

DM Calibration

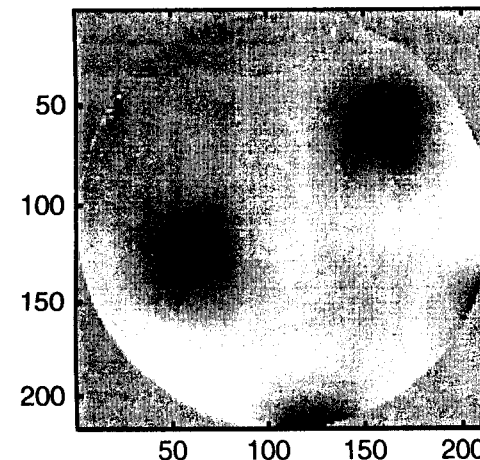WF with flat DM

WF with DM actuator pattern
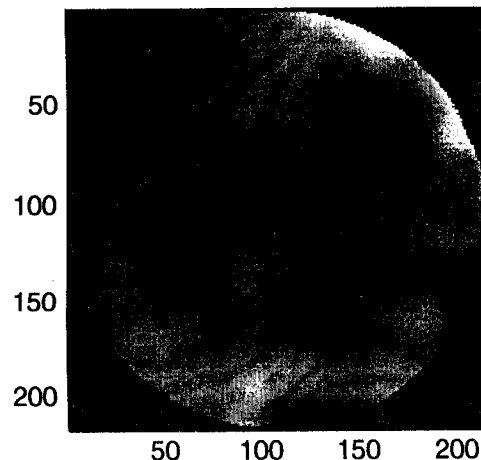
Influence Fcns

- **Flat taken with each DM actuator commanded to 128*63/4096**

- **Next frame shows WF after 4 actuators increasedto 255*63/4096**

- **Difference frame removes common structure**

- **Was repeated actuator-by-actuator, better control resulted**

- **Need to determine levels of nonlinearity**
    - **Quadratic**
    - **Hysteresis**

Typical Closed Loop Results

Aberrated WF — WFE=0.10793

Corrected WF — WFE=0.065162

Control
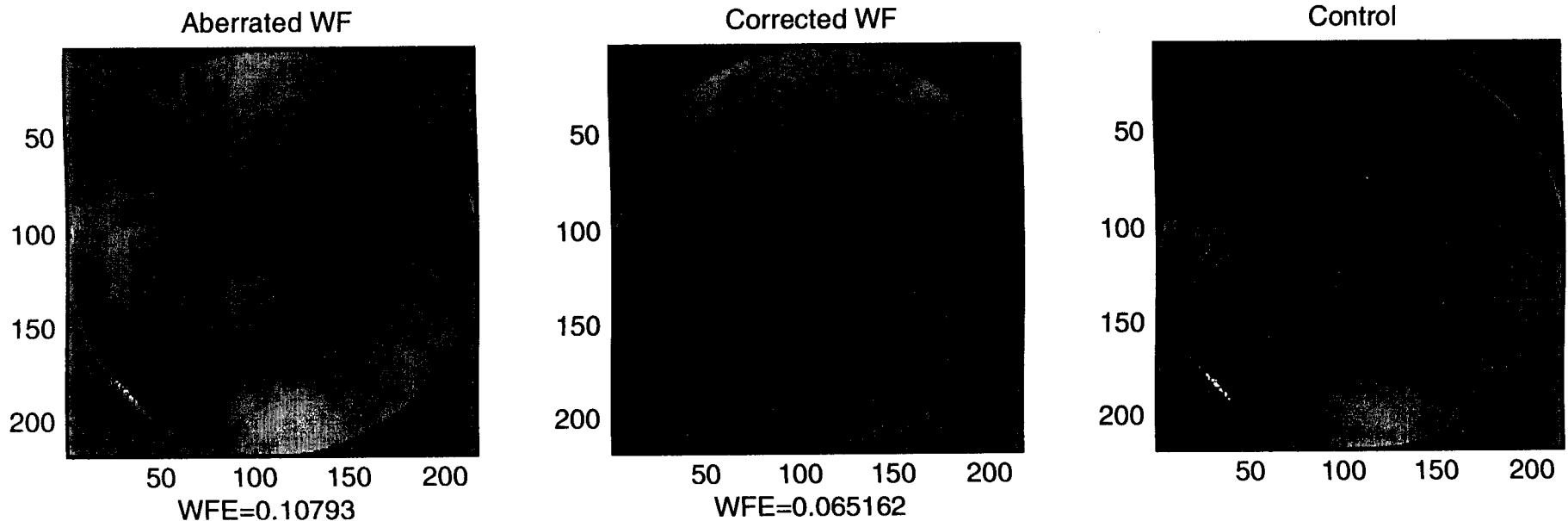
- Shows WF before and after correcting DM (1 iteration only)

- Corrects low-mid spatial freq effects

- Residuals show OAP "gouges", which are smaller than the DM actuators and are not correctable

- Corrected WF is consistently about $\lambda/20$
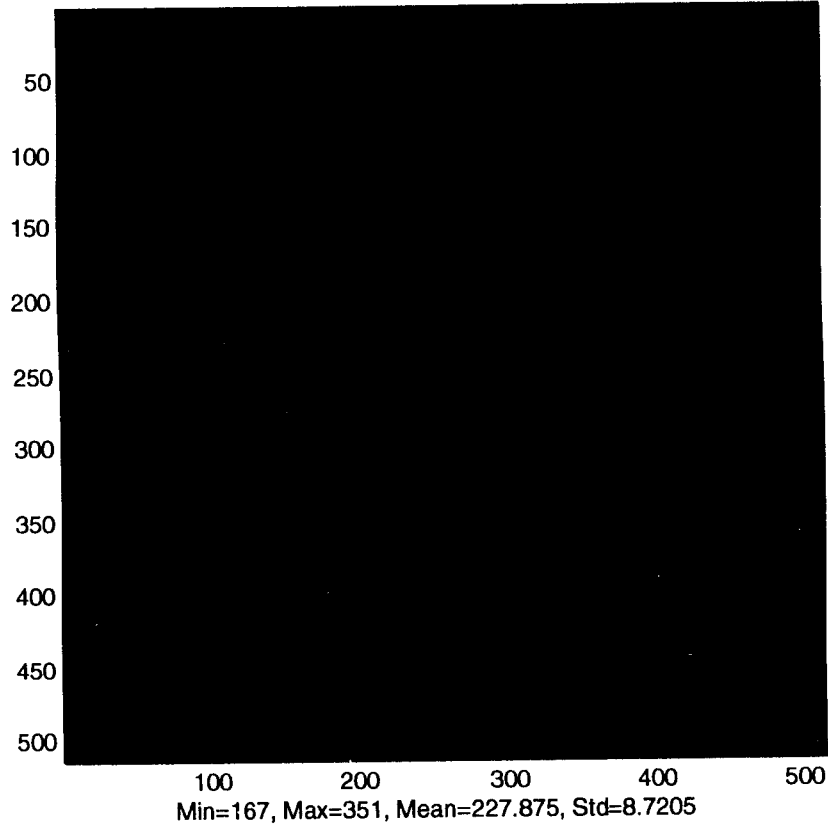
  - DM linearity???

  - DM reset between actuations may be a problem

Dark Frames

Background, 30 sec exposure

Closed shutter, 30 sec exposure

Min=167, Max=351, Mean=227.875, Std=8.7205

Min=65, Max=400, Mean=110.5024, Std=4.0332
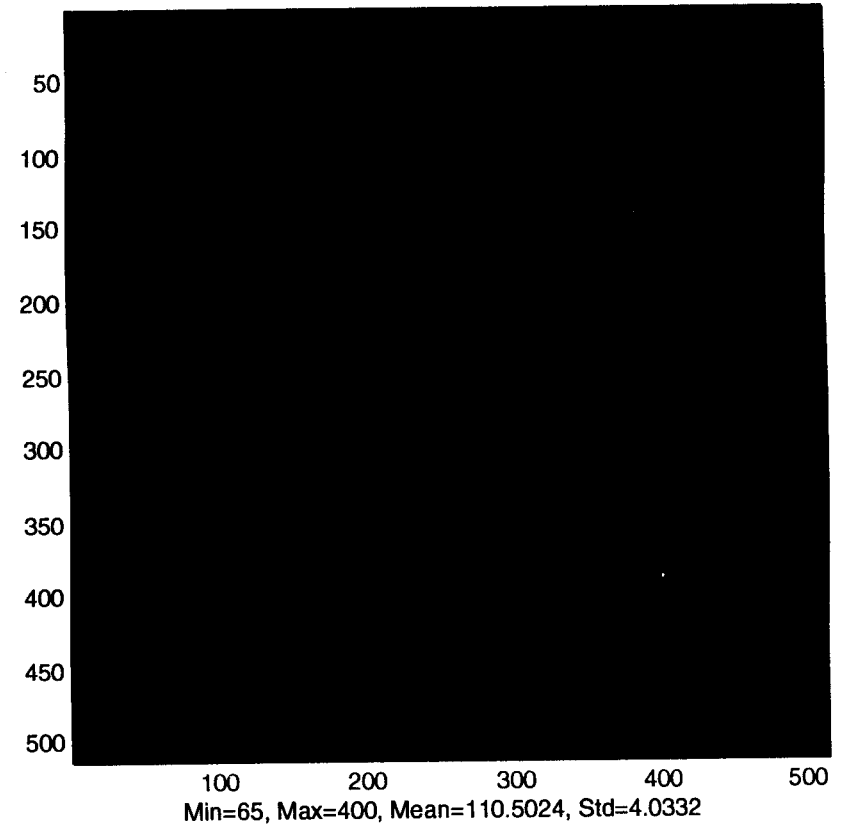
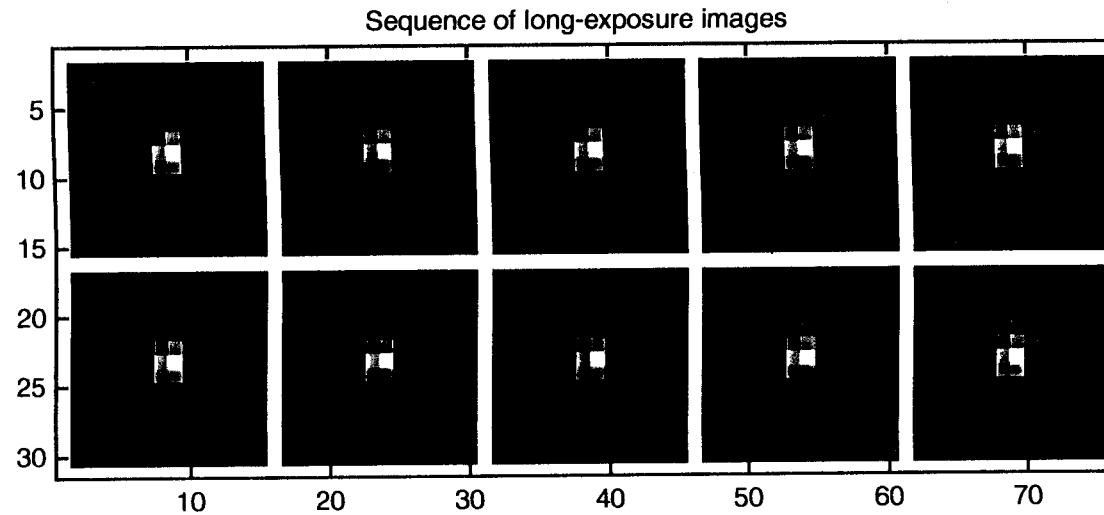- Shutter open frame combines bias, read noise, dark current, stray light
- Shutter closed frame combines bias, read noise and dark current

Jitter and Lab Seeing (cont.)

Sequence of long-exposure images

- **Long exposure images**

Jitter and Lab Seeing
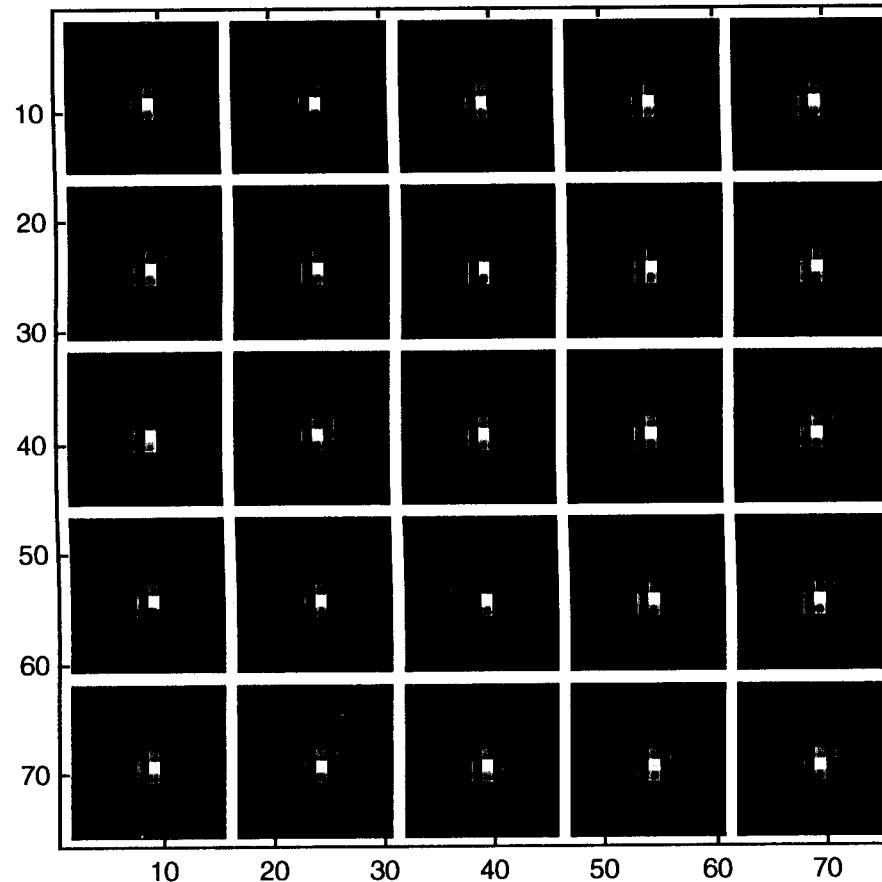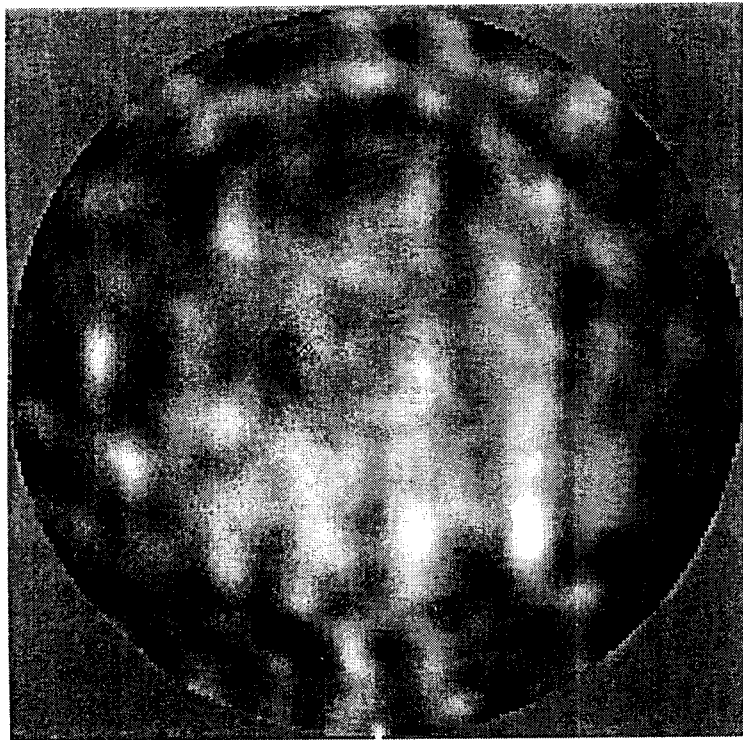

Sequence of short-exposure images

- Sequence of short-exposure images taken to show jitter
  - Lab seeing
  - Mechanical vibration
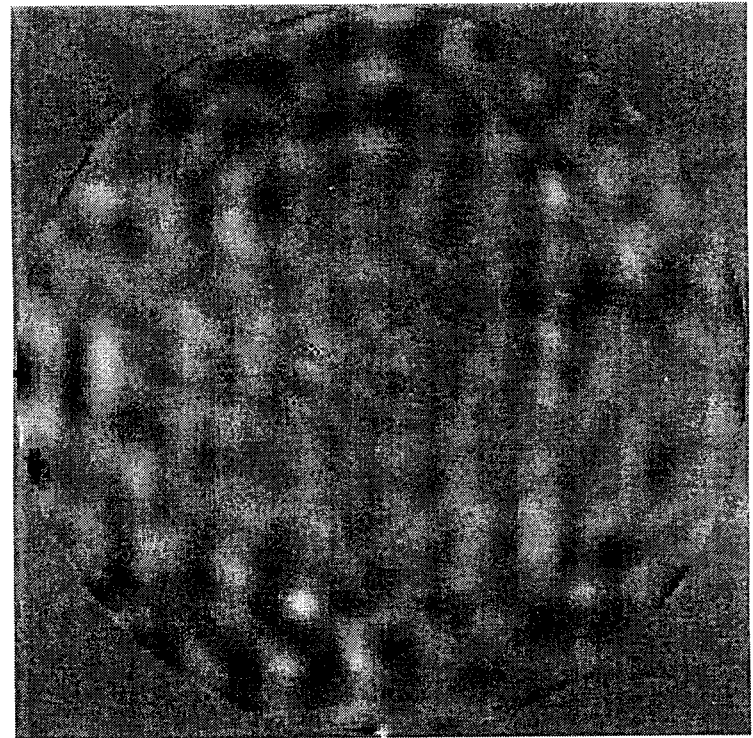 - Shutter speed = 0.1sec

SSAC initial flattening results

Before
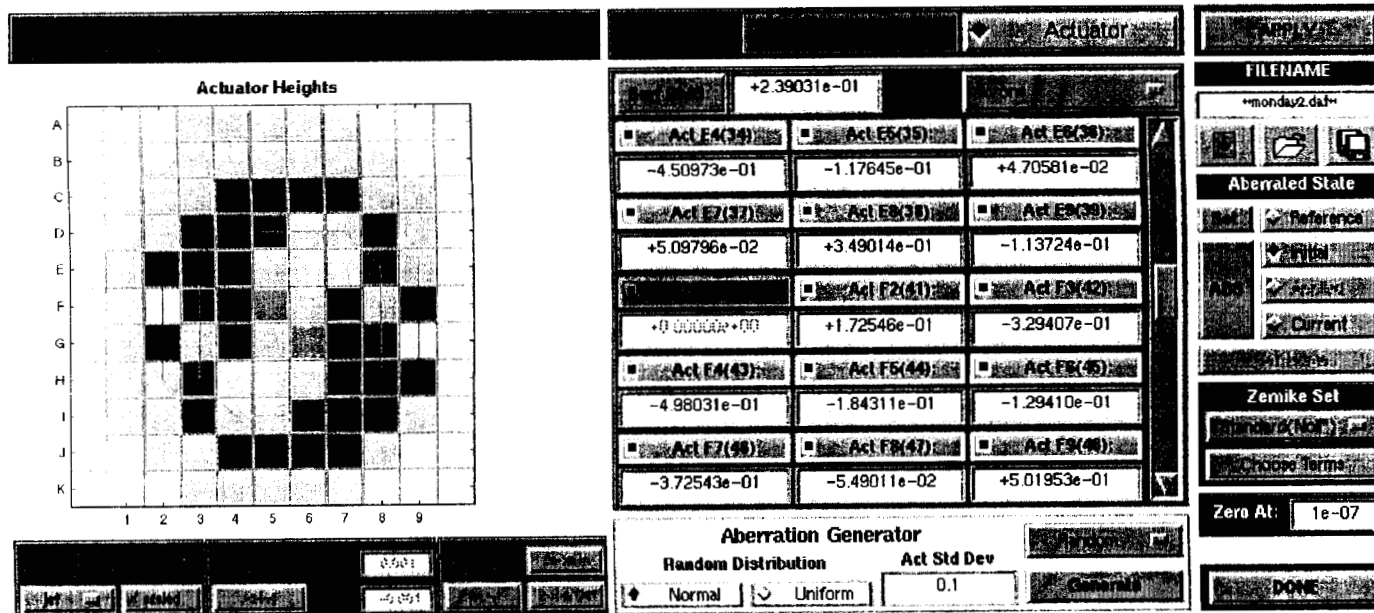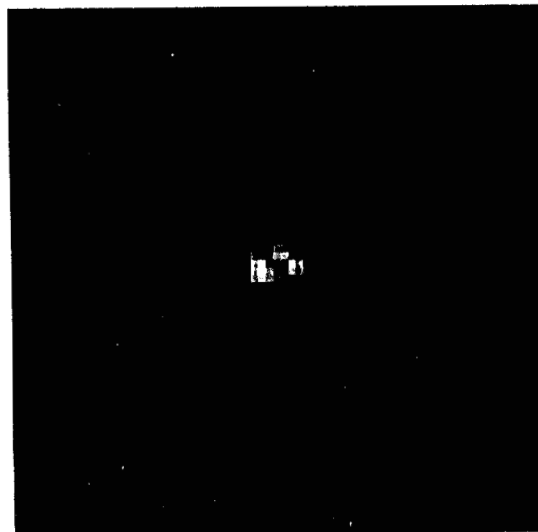
After

RMS wavefront = 0.06439 waves

RMS wavefront = 0.03089 waves

Closed Loop Performance Results

Aberration on Simulator DM

Initial PSF

Initial PSF (log scale)

Wavefront Estimate #1
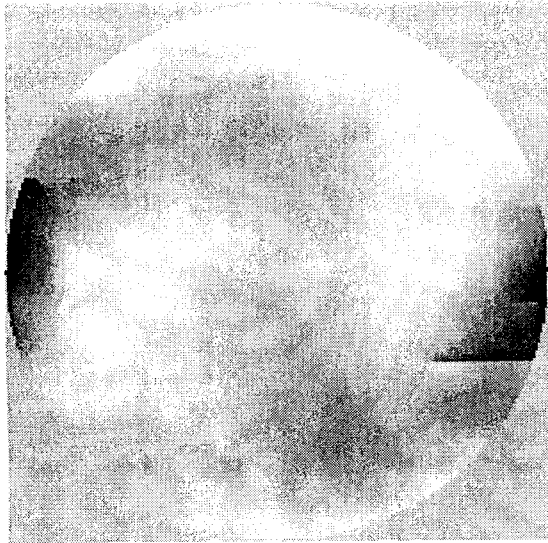
RMS wavefront > 0.30333 waves
Peak-to-Valley = 2.7492 waves

WFC Control Panel

filename   monday2.est   load

Control option   Primary DM control only

Gain   100   %

Compute control   Apply control   Save control   Done

| Resampled estimate | Simulator DM Control | Primary DM Control | Predicted WF |

WFE=0.302   WFE=0.274   WFE=0.108
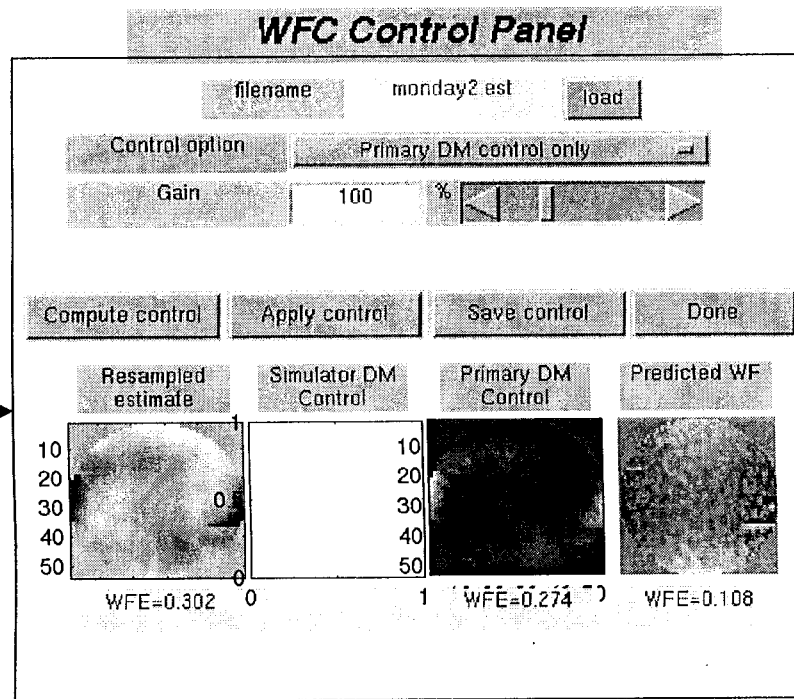
Wavefront Estimate #2

RMS wavefront = 0.25560 waves
Peak-to-Valley = 2.3186 waves
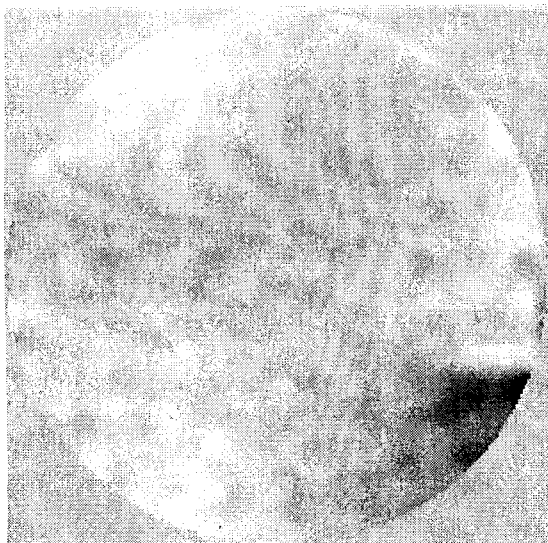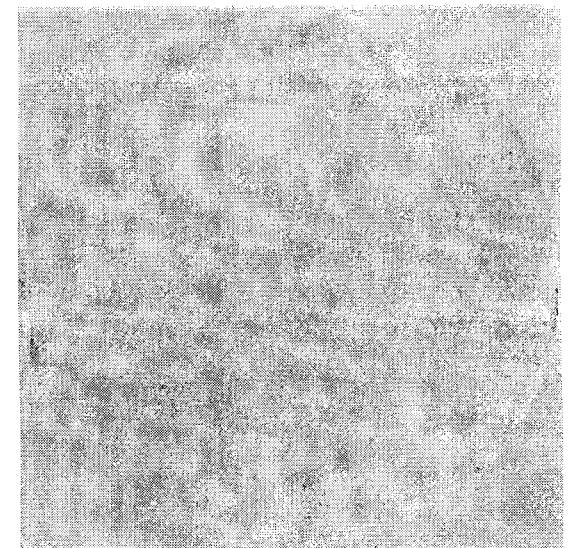
Wavefront Estimate #3

RMS wavefront = 0.16037 waves
Peak-to-Valley = 1.9256 waves
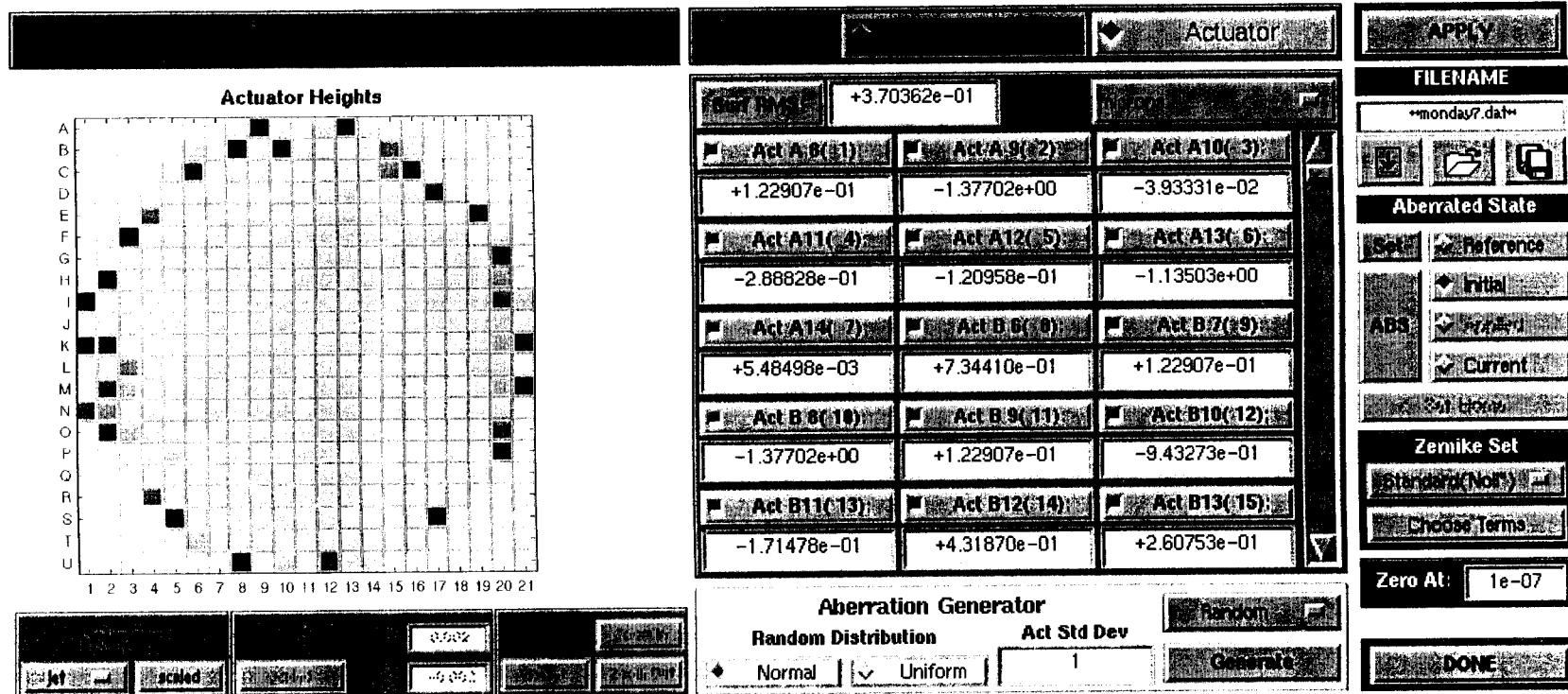
Wavefront Estimate #4

RMS wavefront = 0.07669 waves
Peak-to-Valley = 0.8968 waves
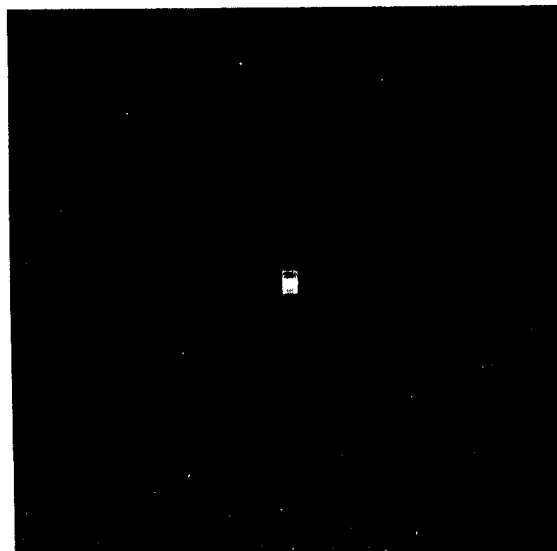
Wavefront Estimate #5

RMS wavefront = 0.04987 waves
Peak-to-Valley = 0.7450 waves

Final correction applied to AODM

Actuator Heights

| | Actuator | APPLY |

| Cur RMS | +3.70362e-01 | RY col |

Act A 8(:1)	Act A 9(:2)	Act A10(:3)
+1.22907e-01	−1.37702e+00	−3.93331e-02

Act A11(:4)	Act A12(:5)	Act A13(:6)
−2.88828e-01	−1.20958e-01	−1.13503e+00

Act A14(:7)	Act B 6(:8)	Act B 7(:9)
+5.48498e-03	+7.34410e-01	+1.22907e-01

Act B 8(:10)	Act B 9(:11)	Act B10(:12)
−1.37702e+00	+1.22907e-01	−9.43273e-01

Act B11(:13)	Act B12(:14)	Act B13(:15)
−1.71478e-01	+4.31870e-01	+2.60753e-01

FILENAME
monday7.dat

Aberrated State

Set — Reference
ABS — Initial
— Prior
— Current
Set Group

Zernike Set
Standard(Norm)
Choose Terms

Zero At: 1e-07

Aberration Generator
Random Distribution — Act Std Dev — Random
◆ Normal | Uniform | 1 | Generate

DONE

Final PSF

Final PSF (log scale)